Vertebral Body Dimensions: An Aid to Diagnosis of Severely Progressive Adolescent Idiopathic Scoliosis?

Following early diagnosis of Adolescent Idiopathic Scoliosis (AIS) it is very difficult to predict whether the curve will continue to increase and to what extent.
A cross-sectional study was conducted to investigate the implications of depth and width dimensions of individual vertebral bodies in adolescents with mild and severely progressive soliosis. Results revealed a tendency for depth/width ratios in severe AIS to increase, and those with mild scoliosis to decrease from 13 to 15 years of age. This was proposed as a basis for an additional tool for diagnosis of severely progressive AIS.

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The prognosis for Adolescent Idiopathic Scoliosis (AIS) is very difficult to predict, subsequent to its early diagnosis in school screening programs. The condition may become stabilized or even be resolved through the growing years. This study investigates the implication of vertebral body dimensions in the progression of AIS.

Several studies of AIS prevalence (Liston 1972; Drummond *et al* 1979) report an almost equal incidence of mild scoliosis amongst males and females, whereas a female to male ratio of approximately 6 : 1 exists amongst those with severe scoliosis requiring treatment. This suggests that some sex related factor influences the behaviour of the curve in girls making it more likely to increase (Drummond 1979).

Bradner (1970) compares vertebral body shape in immature males and females and finds relatively larger vertebral body heights in adolescent females, while adolescent males show consistently larger antero-postero dimensions. Comparison of normal females and females with AIS reveals greater longitudinal growth in those with scoliosis. Taylor and Slinger (1980) report greater thoracolumbar spine lengths in scoliotics, while Burwell and Dangerfield (1977) and Willner (1974) reveal increased growth in certain linear skeletal components.

In the light of these findings a model of spinal stability can be suggested in which the spine is considered as a series of blocks placed one upon the other. Those blocks having a large base and small height dimensions, or low height/width ratios would form a more stable structure. It is hypothesized that those adolescents having vertebral body dimensions with large height/width ratios will have a greater tendency to develop a progressive scoliosis than those with low ratios (Taylor and Slinger 1980).

Materials and Method

A four month study was conducted in which antero-postero, erect, full length X-rays of the vertebral column were obtained for 80 patients who were attending or who had attended the Royal Perth Rehabilitation Hospital. Each patient —

- had been diagnosed as having AIS
- had no other abnormality (ie hormonal, muscular or nervous abnormality or bone deformity other than that of the scoliosis).

Patients were divided into the following categories:

1) non-progressive scoliotic females (NPF), further grouped according to age: 13, 14 and 15 years. In all, the curve was less than 12° in magnitude and remained so until discharge when skeletal maturity was attained. This can be ascertained from X-ray by Rissers sign — ossification of the iliac crests which is also concomitant with fusion of the vetebral ring apophyses of the vertebral bodies.
2) 14-year-old non-progressive scoliotic males (NPM) (Criteria as for 1).
3) Progressive scoliotic females (PF) grouped according to age. 13, 14 and 15 years. The curve was greater than 20° and was continuing or had continued to increase, thus requiring active treatment.

The following measurements were made using a standard protractor and

translucent ruler with millimetre markings.

1) Magnitude of the curve. Two perpendiculars were drawn: from the superior border of the most cephalad vertebral body of the curve, and from the inferior surface of the most caudad vertabral body. The intersection of the lines from these 'end vertebrae' formed the angle of the curve which was then measured with the protactor (Cobb angle).
2) Vertebral dimensions for each of T6, T9 and L1. These were:

- Vertebral width (W) — smallest horizontal diameter across the waist of the vertebral body.
- Vertebral body depth (D) — distance from the middle of the superior surface of the vertebral body to the middle of the inferior surface.

The D/W ratio was then derived —

$$\frac{\text{Vertebral body depth (D)}}{\text{Vertebral body width (W)}}$$

T-tests were performed to derive P values for comparison of D/W values between categories and between age groups. All measurements were carried out by the author to preserve consistency. To reduce bias, all calculations were made following all collection of data and X-rays were measured in random order.

Results

Significantly lower 14-year-old male (NPM) ratios were obtained in comparison with both progressive (PF) and non-progressive females (NPF) aged 13 and 14 years (Table 1).

14 years PF for L1 : $t = 7.01$ $p << 0.0005$
14 years NPF for L1 : $t = 4$ $p << 0.0005$

The curves obtained for D/W values graphed as a function of age are shown in Figure 1, with values shown in Table 1. Ratios decrease singificantly between years 13 and 15 in the non-progressive females.

(T9 : $t = 2.63$ $p < 0.01$ L1 : $t = 2.07$ $p < 0.05$)

However, for progressive scoliotic females, D/W increase significantly at all three vertebral levels between years 13 and 15.

(L1, $t = 3.8$ $p < 0.0005$, T9, $t = 2.35$ $p < 0.01$)

At all vertebral levels significantly lower ratios were obtained at 13 years for progressive scoliotic females compared with non-progressive females.

(T9, $t = 3.65$ $p < 0.001$, L1 : $t = 1.93$ $p < 0.05$)

Discussion

According to the spinal stability model previously proposed, the lower male D/W values compared with females suggest a more stable vertebral column and, therefore, an increased likelihood that females will develop a severe scoliosis.

Table 1:
D/W values obtained for progressive and non-progressive females and non-progressive males for T6, T9 and L1

		Progressive Females			*Non-Progressive Females*			*Non-Progressive Males*		
Age	*Level*	*n*	$\bar{D}/W$	*SD*	*n*	$\bar{D}/W$	*SD*	*n*	$\bar{D}/W$	*SD*
13	T6	17	0.65	0.05	10	0.78	0.07			
	T9	15	0.62	0.07	10	0.72	0.08			
	L1	18	0.62	0.07	10	0.67	0.06			
14	T6	10	0.68	0.05	10	0.74	0.08	10	0.67	0.04
	T9	10	0.67	0.04	10	0.67	0.07	10	0.60	0.06
	L1	10	0.68	0.05	9	0.64	0.09	10	0.54	0.04
15	T6	11	0.72	0.08	10	0.74	0.09			
	T9	9	0.75	0.09	10	0.65	0.05			
	L1	11	0.73	0.08	10	0.61	0.08			

n = number of subjects
$\bar{D}/W$ = the average ratio for that group of subjects
SD = standard deviation

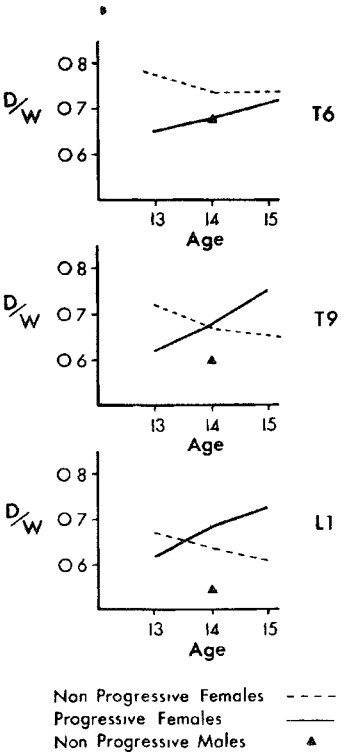

Figure 1: D/W ratios at vertebral levels T6, T9 and L1 for 13, 14 and 15-year-old females with progressive and non-progressive AIS and for 14-year-old males with non-progressive AIS

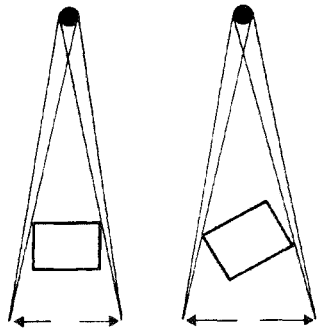

Image A is larger than Image B

Figure 2: A horizontal section through a vertebral body which has been likened to a rectangular prism X-rays from an AP view are shown impinging on —
A — a normally postioned vertebra
B — a rotated vertebra

The decreasing D/W versus age curve obtained for non-progressive scoliotic females suggests that the greater proportionate increase in width dimensions enhances spinal stability so the curve does not increase appreciably.

However, the trend for D/W values to increase in the progressive scoliotic cases may be interpreted as a continuing increase in spinal instability causing the curve to continue to worsen.

It may be argued that the rotation element of severe scoliosis could influence the measurements of the width values from the X-rays. In Figure 2, a vertebral body is likened to a rectangular prism. 'A' shows a section made through the horizontal plane of a 'vertebral body' with X-rays impinging upon it as would occur on an antero-posterior projection. It can be demonstrated that a rotated vertebra would produce a greater width dimension in its projection onto the screen. Because of this, it would be expected that as the scoliosis worsens, the D/W values would gradually decrease. This is contrary to the results obtained for the progressive scoliotic females. If the error from rotation could be excluded, it is possible that the increasing curve pattern would be even more pronounced.

The increased width readings in rotated vertebrae would possibly be a major factor in causing the D/W values for the progressive scoliotic females to be lower than the non-progressives at age 13. However, it is the D/W curve pattern rather than the magnitude of the ratios which seems to characterize a progressive or non-progressive curve.

The different D/W trends observed in progressive and non-progressive curves may have a valuable clinical application in serving as an additional tool in determining whether an adolescent idiopathic curve will remain stable or progress — thereby requiring treatment.

Conclusion

It seems that a trend for depth/width vertebral body dimension ratios to increase from ages 13 to 15 years in females with AIS is associated with a severely progressive scoliosis. Non-progressive scoliosis seems to be associated with decreasing vertebral body depth/width ratios. It is possible that this may serve as an added tool in diagnosis of progressive AIS.

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